PANOCHE DRAINAGE DISTRICT

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September 17, 2004

Michael Delamore
US Bureau of Reclamation
1243 N Street
Fresno CA 93721-1813

Subject: San Joaquin River Water Quality Improvement Project, 2003 Wildlife Monitoring Report

Dear Mike:

Enclosed is the 2003 Monitoring Report for the San Joaquin River Water Quality Improvement Project (SJRIP) prepared by H.T. Harvey & Assoc. This is the third year of bird egg monitoring at the project site. The number of egg samples was significantly increased in 2003 from 2001 and 2002 to better characterize the conditions with a larger sample size. Eggs were collected from black-necked stilt, American avocet, killdeer and red-winged blackbird.

A pasture at the SJRIP attracted waterfowl when it was inadvertently flooded from late April through mid-May 2003. Stilt and avocet eggs collected near the flooded pasture had geometric mean selenium concentrations of 58.2 ppm (dry weight). This caused the overall geometric mean selenium egg concentrations in the project area for stilts and avocets to be 39.0 ppm (dry weight). Equipment and procedures are now in place to prevent a future recurrence of this flooding event, so these elevated egg selenium levels should be a one-time occurrence.

Geometric mean selenium egg concentration for stilt and avocet eggs collected elsewhere in the SJRIP was 15.4 ppm. In comparison, geometric mean selenium egg concentration in ten stilt and avocet eggs collected at an off-site reference location was 17.2 ppm. With the exception of eggs collected near the flooded pasture, geometric mean selenium in stilt and avocet eggs from the SJRIP is lower than at the reference site in the vicinity.

Preliminary data from the 2004 collection indicate that stilt and avocet geometric mean selenium egg concentrations for the entire project area dropped to 15.3 ppm (dry weight). The reference area geometric mean for 2004 was 10.8 ppm.

Questions regarding this data should be directed toward Joe McGahan, Drainage Coordinator for the Grassland Bypass Project. He can be reached at 559-582-9237.

Very truly yours,

Dennis Falaschi
General Manager

Cc: Kathy Wood
US Bureau of Reclamation
1243 N Street
Fresno CA 93721-1813

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

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SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT, PHASE I WILDLIFE MONITORING REPORT 2003

Prepared by:

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File No. 1960-03

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EXECUTIVE SUMMARY

The results of the third year of biological monitoring for Phase I of the San Joaquin River Water Quality Improvement Project are presented in this report. The San Joaquin River Water Quality Improvement Project is designed to reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass. At this point in the project, approximately 1,800 acres, of the 4,000-acre project site, have been planted with salt tolerant crops and irrigated with agricultural drainwater.

An ornithologist from H. T. Harvey & Associates monitored bird use on 2,500 acres of the project site on six occasions, from April 16 to June 13, 2003. As expected in a typical agricultural region, the diversity of avian species found and the number of individuals observed were relatively low for a 2,500-acre site. In addition, the site primarily supported species common in disturbed and ruderal habitats.

H. T. Harvey & Associates' ornithologists collected 20 eggs from the project site for each of three avian species groups: Killdeer, American Avocet and Black-necked Stilt, and Red-winged Blackbird. The collected eggs were analyzed for selenium and boron concentrations. In addition, 11 Killdeer eggs, 10 eggs from the American Avocet and Black-necked Stilt group, and 15 Red-winged Blackbird eggs were collected from the project vicinity, hereafter referred to as the reference area, to provide data on the local "background" concentrations of selenium and boron.

Nearly all analyzed eggs contained partially elevated selenium concentrations. The geometric mean egg-selenium concentrations from the project site were: 12.5 ppm for Killdeer, 39.0 ppm for recurvirostrids (Black-necked Stilt and American Avocet combined and 5.9 ppm for Red-winged Blackbirds. For the reference area, the geometric mean egg-selenium concentrations were 4.0 ppm, 17.2 ppm and 4.2 ppm, respectively. The mean selenium levels in eggs collected from the reference area were significantly lower than those from the project site (t-tests, all $P < 0.01$) for all three species groups.

Several of the project-site Killdeer and recurvirostrid eggs were collected from an accidentally flooded pasture. Recurvirostrid eggs collected from this pasture contained significantly higher egg-selenium concentrations than recurvirostrid eggs collected from either the remainder of the project site or the reference area. There was no significant difference in selenium concentrations in recurvirostrid eggs collected from the remainder of the project site and eggs collected from the reference area. Killdeer eggs collected from the flooded pasture did not contain significantly higher levels of selenium than Killdeer eggs collected from the remainder of the project site, both of which contained significantly higher selenium concentrations than eggs collected from the reference area. Panoche Drainage District now has equipment and procedures in place to prevent a future recurrence of this flooding event, which appears to have increased mean selenium uptake in recurvirostrids relative to the rest of the project site.

Most of recurvirostrid eggs collected at the project site contained egg-selenium concentrations greater than 18 ppm, values associated with a high probability of reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis). Killdeer eggs contained selenium concentrations within the range (8-18 ppm dry wt) associated with increased probability of reduced hatchability.

The boron analysis of eggs collected from the project site revealed that the three avian species groups all had egg boron concentrations at or above the 3 ppm dry weight measured in the reference samples: Killdeer mean = 2.49 ppm, range = 1.10-5.26 ppm; recurvirostrids mean = 2.46 ppm, range = 0.69-4.33 ppm; and Red-winged Blackbirds mean = 5.06 ppm, range = 1.53-12.5 ppm. The elevated boron content in eggs collected from the project site indicates that boron levels should continue to be monitored.

INTRODUCTION

To reduce the amount of salt and selenium delivered to the San Luis Drain and Mud Slough through the Grassland Bypass Project, the Panoche Drainage District implemented Phase I of the San Joaquin River Water Quality Improvement Project (SJRIP). The Panoche Drainage District, acting as the lead agency under the California Environmental Quality Act (CEQA), prepared a Negative Declaration for SJRIP in September 2000. The Negative Declaration included the provision of a biological monitoring program, to be developed in collaboration with the U. S. Fish and Wildlife Service (the Service), which would detect migratory bird impacts resulting from the project. This report represents the biological monitoring results for the third year (2003) of Phase I of the SJRIP.

PROJECT DESCRIPTION AND SETTING

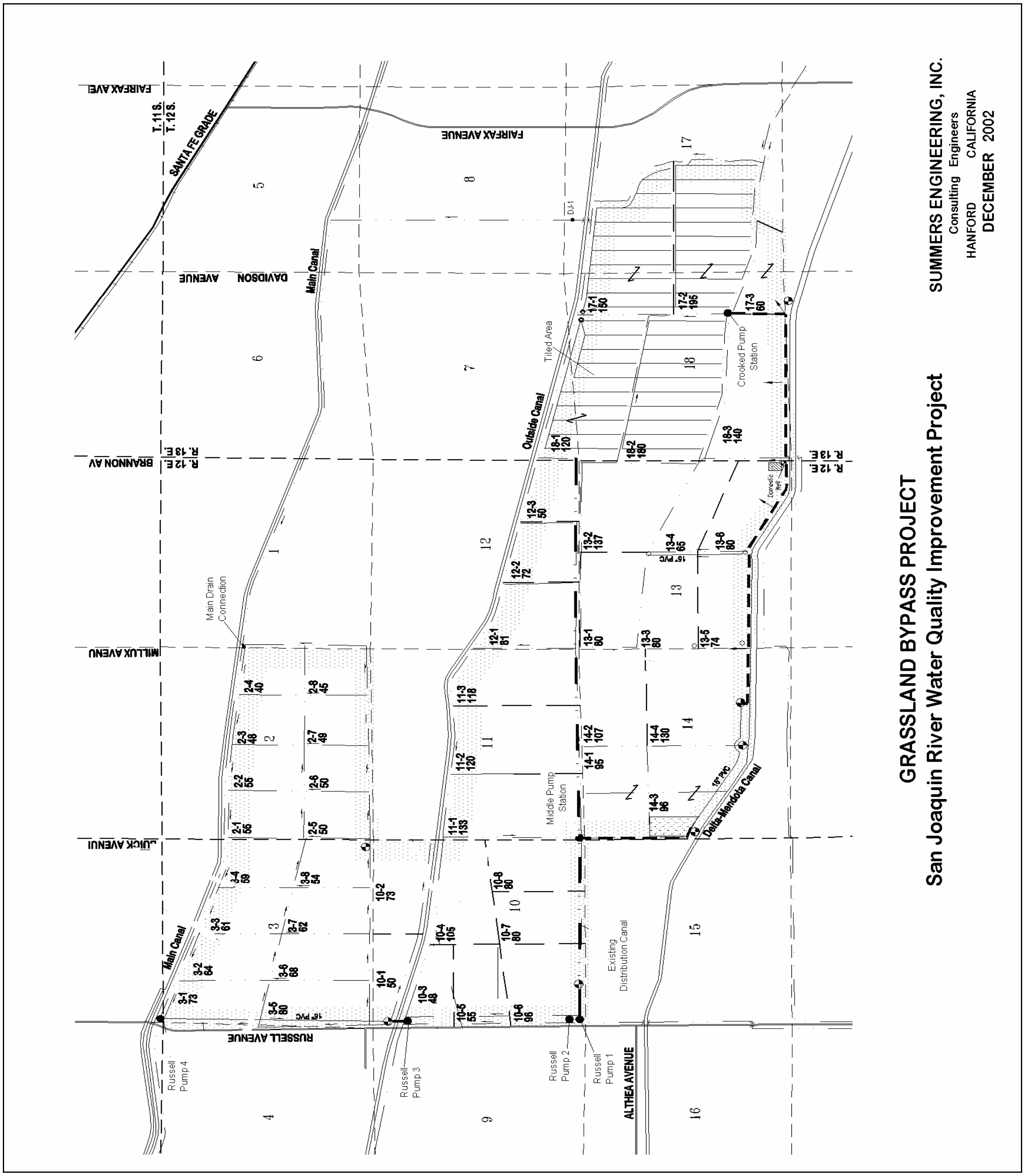
Only a portion of Phase I was put into effect in 2003. Crops were planted on approximately 1,800 of the 4,000 acres obtained by the Panoche Drainage District. The project site is located west of the city of Firebaugh in Fresno County, California. The irregularly shaped project site is bordered on the north by the Main Canal and on the south by the Delta-Mendota Canal. Russell Avenue borders the eastern edge of the project site and the western edge extends nearly to Fairfax Avenue (Figure 1).

The project is the initial development of an In-Valley Treatment/Drainage Reuse Facility on up to 6,200 acres of land within the Grassland Drainage Area (GDA) (Figure 1). The 6,200 acres of GDA land designated for purchase is made up of irrigated field crops and related irrigation ditches, drain ditches, conveyance canals and farm structures. The topography is nearly level to grade and flood/furrow irrigated. The highest elevation is found near the southeast corner at 164 feet above mean sea level, while the lowest point is found near a north-central point at 136 feet above mean sea level. Thus, the elevation change within the 6,200-acre property is approximately 28 feet. The shape of the property is irregular, conforming to the area’s adjacent canals. Russell Avenue provides access to the property via a paved county road. Typical, improved farm roads provide access to the interior of the site.

The reuse facility will dedicate specific lands for the irrigation of salt-tolerant crops with subsurface drainwater to reduce drainwater volume; treat the concentrated drainwater to remove salt, selenium and boron; and eventually dispose of the removed elements to prevent discharge into the San Joaquin River. The reuse facility will process up to one-quarter of the total drainwater produced in the GDA (25 percent of 52,000 acre-feet or approximately 15,000 acre-feet) and will be implemented in three phases, described below:

- Phase I: Purchase of land and planting of salt-tolerant crops
- Phase II: Installation of subsurface drainage and collection systems, initial treatment system
- Phase III: Complete construction of treatment removal and salt disposal systems

Figure 1. Location of the Panoche Drainage District's San Joaquin River Water Quality Improvement Project.



In Phase I, subsurface drainwater from the GDA is used to irrigate salt-tolerant crops on ideally situated land. Channels containing collected drainwater flow adjacent to this location, so water can easily be captured and placed on the land. Also, because this land is at the lowest elevation within the drainage area, collected water can be applied without excessive pumping costs.

Approximately four thousand acres have been purchased by the Panoche Drainage District to date. Approximately 1,800 acres of crops were planted in 2001 and irrigated with water that otherwise would have been discharged into the San Joaquin River. Soil and water constituents at this project site will continue to be monitored in order to prevent irreversible soil changes and to protect groundwater from contamination.

In Phase II of the SJRIP, the application of saline water to lands developed in Phase I will continue. Subsurface drainage systems will be installed to leach the land and maintain a favorable salt balance. The water percolating below the root zone will be captured in the drainage system and passed on to more salt-tolerant crops. In Phase II, the system will sequentially reuse drainwater on increasingly salt-tolerant crops to concentrate, and decrease, the volume of drainwater produced. Salt, selenium and other constituents will be conveyed by water exiting the subsurface drainage systems. An initial treatment phase will remove the salt, the selenium and much of the other constituents, leaving water for beneficial uses such as agriculture. The treatment system will be designed to incorporate into the reuse system at any point. The remaining salt will be deposited into approved waste units, which will result in additional reductions in salt and selenium discharges into the San Joaquin River.

The third and final phase of the SJRIP will maximize improvement in water-quality and meet reductions needed for future water-quality objectives. This phase will expand the initial treatment (under Phase II) to include additional treatment facilities and waste-disposal units.

Each phase of the facility will significantly reduce the amount of drainwater discharged to the San Joaquin River. Water sufficient for reuse on GDA agricultural lands could also be produced by the treatment systems. The project will be designed to assist Grasslands Area Farmers in meeting applicable water-quality objectives for the 2006 water year (October 1, 2005). The 2006 annual, selenium-load limit, based on the current applicable total maximum monthly load, is 3,087 pounds. In comparison, the load value for the 2001 water year was 5,661 lbs. This reduction in load size requires implementation of additional drainage management methods.

An Initial Study and Negative Declaration, adopted September 9, 2000 by Panoche Drainage District, evaluated Phase I of the facility. The second and third phases of the facility were evaluated in the Grassland Bypass Project EIS/EIR, finalized May 25, 2001. Phase I is independent and does not exclude the consideration of alternatives to the larger project or project site. Even if the In-Valley Treatment/Drainage Reuse Project progress was to halt at Phase I, the drainage management alone would be valuable. In addition, the proposed cropping patterns are reversible should later phases of the project not be implemented.

In 1997, a portion of the project site was evaluated for conversion to salt-tolerant crops and drainage reuse by Mercy Springs Water District, which encompasses 3,392 acres (55 percent) of the site. The Mercy Springs Water District prepared an Environmental Assessment for the transfer of its Central Valley Project Class I water supply to the Pajaro Valley Water Management Agency (ESA 1997). A Finding of No Significant Impact approved the transfer of

13,300 acre-feet of annual water supply to the Pajaro Valley Water Management Agency on November 6, 1998. In 1999, a Final Environmental Assessment and Finding of No Significant Impact were issued for the transfer of 6,260 acre-feet per year of annual Central Valley Project contract water to the Pajaro Valley Water Management Agency, Santa Clara Valley Water District and Westlands Water District (Provost & Pritchard 1999). These documents covered the impact of water transfers, including drainwater reuse, groundwater pumping and cumulative effects. The current phase of the proposed In-Valley Project does not include water transfers or additional groundwater pumping over existing conditions.

MATERIALS AND METHODS

BIRD CENSUSES

An ornithologist from H. T. Harvey & Associates monitored bird use at the project site on six occasions from April 16 to June 13, 2003. Censuses were completed by driving the perimeter roads of each field. Birds were identified and counted using 10X binoculars and a 20-60X spotting scope mounted on a tripod. Censuses were conducted to determine species composition and relative abundance of bird species on the project site during the breeding season.

EGG COLLECTION AND PROCESSING

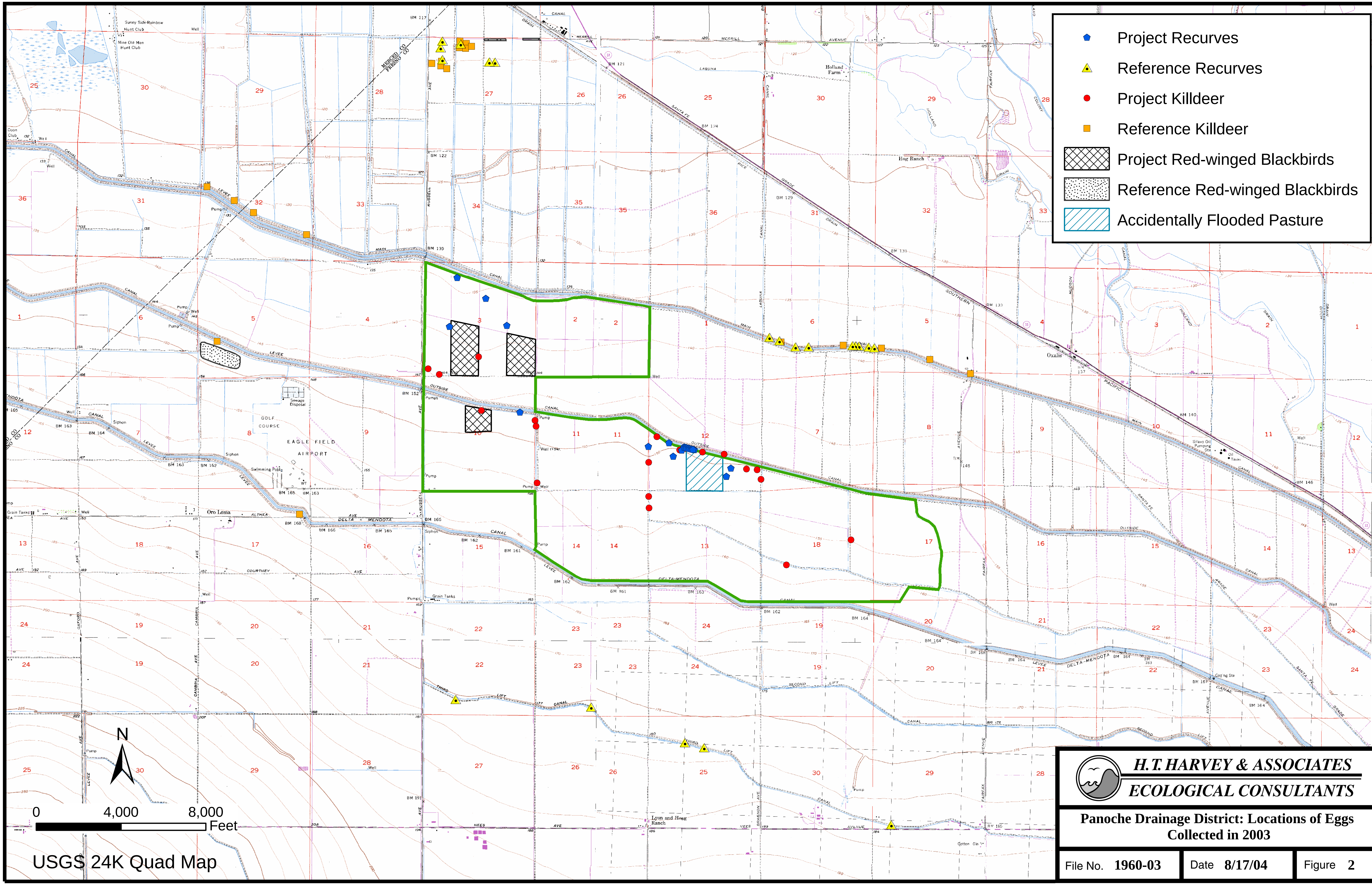
Twenty Killdeer (*Charadrius vociferus*) eggs, 20 eggs from American Avocets (*Recurvirostra americana*) or Black-necked Stilts (*Himantopus mexicanus*) (recurvirostrids) and 20 Red-winged Blackbird eggs were collected from the project site for selenium and boron analysis. The locations from which eggs were collected are illustrated in Figure 2. A scientific collecting permit was obtained from the California Department of Fish and Game (CDFG) for the collection of bird eggs on the site. One egg was randomly collected from separate, full-clutch (four eggs) nests. Three additional sets of 20 reference Killdeer, recurvirostrid and Red-winged Blackbird eggs were collected (Figure 2) from the project vicinity to provide reference data on background selenium and boron concentrations.

All eggs were labeled with a permanent marker, placed in an egg carton and transported from the field. Upon returning to the lab, all of the egg contents (including membranes) were removed from the shell and transferred to one oz. Dynalon jars. The embryos were photographed and examined for abnormalities and to determine the stage of incubation (age). Eggs were also examined to determine whether embryos were alive or dead. Egg contents were stored by freezing ($0\,^{o}$ C).

EGG-SELENIUM ANALYSIS

All egg contents collected by H. T. Harvey & Associates were shipped overnight, on dry ice, to the Oscar E. Olson Biochemical Laboratory at South Dakota State University. For quality control, selected sub-samples were divided into two aliquots. The duplicate was spiked with known amounts of selenium and the samples were tested to determine the accuracy of analysis. Selenium concentrations were determined using hydride generation atomic absorption. All egg-selenium concentrations were presented as parts per million (ppm) based on dry tissue weight (dry weight).

Using STATA (Stata Corp 1995), multiple regression analyzes were used to statistically examine relationships between egg-selenium levels, bird species groups and sites (project versus reference). Selenium and boron concentration values were log-transformed (log base 10) to satisfy assumptions of normality in the regression models (Skewness/Kurtosis Test for Normality of Residuals, P >0.05). A Sidak one-way *ANOVA* (an improved version of the Bonferroni multiple-comparisons test; SAS Inst. 1985) was used to compare selenium and boron concentrations among the three avian species groups.


Project Recurves
Reference Recurves
Project Killdeer
Reference Killdeer
Project Red-winged Blackbirds
Reference Red-winged Blackbirds
Accidentally Flooded Pasture
N
0
4,000
8,000
Feet
USGS 24K Quad Map
EAGLE FIELD AIRPORT
Oro Loma
Holland Farm
Hog Ranch
H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS
Panoche Drainage District: Locations of Eggs Collected in 2003
File No. 1960-03
Date 8/17/04
Figure 2

RESULTS

BIRD CENSUSES

In the Phase I area, 45 avian species were observed between April 16 and June 4, 2003 (Table 1). Avian numbers were highest in April, when Cattle Egrets (*Bublucus ibis*) and migrating shorebirds such as Black-bellied Plovers (*Pluvialis squatarola*), Whimbrels (*Nunenius phaeopus*), Western Sandpipers (*Calidris mauri*) and Dunlin (*C. alpina*) were present (Table 1). Red-winged Blackbirds (*Agelaius phoeniceus*) were the most numerous avian species observed on the project site. Eighteen species were either observed nesting on the site, or nesting was suspected, based on observations of courtship behavior or young. Numbers declined in May and June as fewer migrants were detected.

EGG COLLECTION AND PROCESSING

Sixty eggs including 20 Killdeer, 20 recurvirostrid (nine Black-necked Stilt and 11 American Avocet) and 20 Red-winged Blackbird eggs were collected from the project site. Five of the Killdeer embryos were more than nine days old, were alive and in normal condition. Another 9 Killdeer embryos were alive, but too young (three to nine days old) to determine their condition. The remaining six Killdeer embryos were less than three days old (Table 2). One of the recurvirostrid eggs contained a live, normal 20-day-old embryo. The remaining stilt and avocet embryos were too young (less than nine days old) to determine the embryo condition, though four were old enough (more than three days old) to determine that they were alive (Table 3). All 20 of the Red-winged Blackbirds were too undeveloped for their condition to be assessed, though five were developed enough (they contained feathered embryos), to determine that they were alive (Table 4).

Sixty eggs including 20 Killdeer, 20 recurvirostrid (16 Black-necked Stilts and four American Avocets) and 20 Red-winged Blackbird eggs were collected from the vicinity of the project site. Four of the Killdeer embryos from the reference area were more than nine days old, were alive and in normal condition. Another eight Killdeer embryos were alive, but too young (three to nine days old) to determine their condition. The remaining eight Killdeer embryos were less than three days old (Table 5). Three of the recurvirostrid eggs contained a live, normal 20-day-old embryo. The remaining stilt and avocet embryos were too young (less than nine days old) to determine the embryo condition, though five were old enough (more than three days old) to determine that they were alive (Table 6). All 20 of the Red-winged Blackbirds were too undeveloped for their condition to be assessed or to determine if they were alive (Table 7).

Table 1. Avian census results at Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

		2003					
	Species	**April 16**	**April 23**	**April 29**	**May 06**	**May 23**	**June 04**
	Great Blue Heron	2	1		1	1	1
	Great Egret	5	9	11	1	1	
	Snowy Egret	8	21	14	3	2	3
	Cattle Egret	44	152	10			
	White-faced Ibis	72	106	84	62	33	21
*	Mallard	16	104	74	49	10	14
	Northern Pintail	6	19	24			
*	Cinnamon Teal	4	87	66	43	25	18
*	Gadwall	2	18	15	4		
	Northern Harrier	2	1	4	4	3	2
	Swainson's Hawk	2	3	2	2	4	2
*	Red-tailed Hawk	6	10	8	8	7	8
	American Kestrel	1	3	2	2	2	2
*	Ring-necked Pheasant		1	1		15	
	Black-bellied Plover	8	133	71			
*	Killdeer	19	25	35	39	34	33
*	Black-necked Stilt	35	129	134	105	56	53
*	American Avocet	28	104	87	79	68	44
	Greater Yellowlegs	3	11	1			
	Whimbrel	162	190	80	31	6	
	Long-billed Curlew	4	39	2			
	Western Sandpiper	14	162	144	7		
	Least Sandpiper	13	46	18	16	5	
	Dunlin		113	56	35		
	dowitcher sp.	4	68	41	19		
	Wilson's Phalarope		6	4			
	Black Tern			1	2	2	5
	Mourning Dove	14	12	17	15	12	10
*	Burrowing Owl	2	3	3	4	2	3
*	Western Kingbird	22	23	25	24	24	26
*	Loggerhead Shrike	5	4	4	5	4	4
	Common Raven	7	56	103	10	8	7
*	Horned Lark	21	10	8	6	4	6
	Barn Swallow	4	1	2	1		3
	Cliff Swallow		18		5		
	American Pipit	75	81	4			
	Savannah Sparrow	28	20	14	4		
*	Song Sparrow	14	19	15	16	14	16
*	Red-winged Blackbird	262	305	340	320	300	240
	Tricolored Blackbird	56	11	26			
*	Western Meadowlark	21	26	24	23	25	31
*	Brewer's Blackbird	41	36	37	31	25	26
	Brown-headed Cowbird	24	34	35	18	9	11
*	House Finch	26	24	29	15	16	2
*	House Sparrow	10	15	13	16	11	7
	Total	**1092**	**2259**	**1688**	**1025**	**728**	**598**
	* = Species for which evidence of nesting was observed this year.						

Table 2. Project site Killdeer concentrations at Panoche Drainage Districts San Joaquin River Quality Improvement Project.

ID Number	Flooded Pasture Yes/No	Species	Date 2003	Embryo Condition [a]	Status [b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	Yes	Killdeer	April 23	U	U	<3	18.6	1.2695	
02	No	Killdeer	April 29	L	N	12-15	13.8	1.1399	
03	No	Killdeer	April 29	L	U	6	14.1	1.1492	
04	No	Killdeer	May 01	L	U	6-9	8.5	0.9294	
05	Yes	Killdeer	May 01	U	U	<3	7.4	0.8692	
06	Yes	Killdeer	May 09	U	U	<3	18.3	1.2625	
07	No	Killdeer	May 12	U	U	<3	10.3	1.0128	
08	Yes	Killdeer	May 12	L	U	6-9	33.5	1.5250	
09	Yes	Killdeer	May 16	L	U	<3	15.4	1.1875	
10	No	Killdeer	May 16	L	N	17-19	16.9	1.2279	
11	No	Killdeer	June 02	L	U	3-6	10.8	1.0334	
12	No	Killdeer	June 11	L	U	3-6	9.4	0.9731	
13	Yes	Killdeer	June 11	L	U	3-6	8.2	0.9138	
14	Yes	Killdeer	June 11	L	U	3-6	9.7	0.9868	
15	Yes	Killdeer	June 17	L	U	3-6	18.2	1.2601	
16	No	Killdeer	June 17	L	N	12	13.1	1.1173	
17	Yes	Killdeer	June 17	L	N	17	10.4	1.0170	
18	Yes	Killdeer	June 24	L	U	6-9	14.6	1.1644	
19	Yes	Killdeer	June 24	L	N	17-18	14.1	1.1492	
20	No	Killdeer	June 24	U	U	<3	5.8	0.7634	
Arith/**Geo Mean**							13.6	1.0976	**12.5**
SD							6.1	0.1739	**1.5**
SE								0.0778	**1.2**
95% CI								0.9452	**8.8**
								1.2500	**17.8**

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 3. Project site recurvirostrid egg-selenium concentrations at Panoche Drainage District's San Joaquin River Quality Improvement Project.

ID Number	Flooded Pasture Yes/No	Species	Date 2003	Embryo Condition[a]	Embryo Status[b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	Yes	Black-necked Stilt	April 23	U	U	6-9	50.5	1.7033	
02	Yes	Black-necked Stilt	April 29	U	U	<3	32.8	1.5159	
03	Yes	American Avocet	April 29	U	U	<3	63.8	1.8048	
04	Yes	American Avocet	April 29	U	U	<3	50.0	1.6990	
05	Yes	American Avocet	April 29	U	U	<3	98.9	1.9952	
06	Yes	American Avocet	April 29	U	U	<3	38.9	1.5899	
07	Yes	Black-necked Stilt	April 29	L	U	3	40.9	1.6117	
08	Yes	American Avocet	April 29	U	U	<3	71.8	1.8561	
09	Yes	Black-necked Stilt	April 29	U	U	<3	50.3	1.7016	
10	Yes	American Avocet	April 29	U	U	<3	74.0	1.8692	
11	Yes	American Avocet	April 29	U	U	<3	74.9	1.8745	
12	Yes	Black-necked Stilt	April 29	U	U	<3	58.7	1.7686	
13	Yes	American Avocet	May 01	U	U	<3	64.8	1.8116	
14	No	Black-necked Stilt	May 01	U	U	<3	11.0	1.0414	
15	No	American Avocet	May 09	U	U	<3	14.3	1.1553	
16	No	Black-necked Stilt	May 09	U	U	<3	32.3	1.5092	
17	No	Black-necked Stilt	May 12	L	U	9?	26.5	1.4232	
18	No	Black-necked Stilt	May 16	L	U	<6	9.8	0.9912	
19	Yes	American Avocet	May 16	L	N	20+	80.2	1.9042	
20	No	American Avocet	May 23	L	U	3-6	10.1	1.0043	
Arith/**Geo Mean**							47.7	1.5915	**39.0**
SD							25.9	0.3153	**2.1**
SE								0.1410	**1.4**
95% CI								1.3152	**20.7**
								1.8679	**73.8**

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 4. Project site Red-winged Blackbird egg-selenium concentrations at Panoche Drainage District's San Joaquin River Quality Improvement Project.

ID Number	Species	Date 2003	Embryo Condition [a]	Embryo Status [b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	R.W. Blackbird	April 25	U	U	yolk	4.9	0.6902	
02	R.W. Blackbird	April 25	U	U	yolk	6.0	0.7782	
03	R.W. Blackbird	April 25	L	U	unfeathered	5.7	0.7559	
04	R.W. Blackbird	April 25	U	U	yolk	5.7	0.7559	
05	R.W. Blackbird	April 25	L	U	unfeathered	6.4	0.8062	
06	R.W. Blackbird	May 01	U	U	yolk	5.4	0.7324	
07	R.W. Blackbird	May 01	U	U	yolk	5.5	0.7404	
08	R.W. Blackbird	May 01	U	U	yolk	5.2	0.7160	
09	R.W. Blackbird	May 01	U	U	yolk	5.6	0.7482	
10	R.W. Blackbird	May 01	U	U	yolk	6.1	0.7853	
11	R.W. Blackbird	May 01	U	U	yolk	4.9	0.6902	
12	R.W. Blackbird	May 05	U	U	yolk	9.4	0.9731	
13	R.W. Blackbird	May 05	U	U	yolk	4.8	0.6812	
14	R.W. Blackbird	May 05	L	U	unfeathered	8.5	0.9294	
15	R.W. Blackbird	May 05	L	U	unfeathered	6.0	0.7782	
16	R.W. Blackbird	May 05	L	U	unfeathered	5.5	0.7404	
17	R.W. Blackbird	May 05	U	U	yolk	11.0	1.0414	
18	R.W. Blackbird	May 05	U	U	yolk	4.7	0.6721	
19	R.W. Blackbird	May 05	U	U	yolk	5.3	0.7243	
20	R.W. Blackbird	May 05	U	U	yolk	4.5	0.6532	
Arith/**Geo Mean**						6.1	0.7696	**5.9**
SD						1.7	0.1013	**1.3**
SE							0.0453	**1.1**
95% CI							0.6808	**4.8**
							0.8584	**7.2**

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 5. Reference area Killdeer egg-selenium concentrations at Panoche Drainage District's San Joaquin River water Quality Improvement Project.

ID Number	Rice Field Yes/No	Species	Date 2003	Embryo Condition [a]	Status [b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	No	Killdeer	May 05	L	U	3-6	7.5	0.8751	
02	No	Killdeer	May 05	L	U	3-6	2.6	0.4150	
03	No	Killdeer	May 06	L	U	3-6	2.7	0.4314	
04	No	Killdeer	May 12	U	U	<3	3.5	0.5441	
05	No	Killdeer	May 12	U	U	<3	4.1	0.6128	
06	No	Killdeer	May 16	U	U	<3	10	1.0086	
07	No	Killdeer	May 23	L	N	16	3.5	0.5441	
08	No	Killdeer	May 23	L	U	3-6	3.4	0.5315	
09	No	Killdeer	June 02	L	N	15	4.1	0.6128	
10	No	Killdeer	June 02	L	N	20	4.3	0.6335	
11	Yes	Killdeer	June 04	L	U	3-6	3.2	0.5051	
12	Yes	Killdeer	June 04	U	U	<3	3.9	0.5911	
13	Yes	Killdeer	June 04	U	U	<3	3.5	0.5441	
14	Yes	Killdeer	June 04	U	U	<3	5.7	0.7559	
15	Yes	Killdeer	June 11	U	U	<3	2.7	0.4314	
16	Yes	Killdeer	June 11	L	U	6-8	4.0	0.6021	
17	Yes	Killdeer	June 11	L	U	6-8	3.6	0.5563	
18	Yes	Killdeer	June 11	L	N	19	7.1	0.8513	
19	Yes	Killdeer	June 11	U	U	<3	3.2	0.5051	
20	No	Killdeer	June 17	L	U	3-6	2.8	0.4472	
Arith/**Geo Mean**							4.3	0.5999	**4.0**
SD							1.93	0.1589	**1.4**
SE								0.0711	**1.2**
95% CI								0.4606	**2.9**
								0.7392	**5.5**

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 6. Reference area Recurvirostrid egg-selenium concentrations at Panoche Drainage District's San Joaquin River water Quality Improvement Project.

ID Number	Rice Field Yes/No	Species	Date 2003	Embryo Condition [a]	Embryo Status[b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	No	Black-necked Stilt	April 25	U	U	<3	40.6	1.6085	
02	No	Black-necked Stilt	May 01	U	U	<3	24.1	1.3820	
03	No	Black-necked Stilt	May 06	U	U	<3	18.3	1.2625	
04	No	American Avocet	May 09	U	U	<3	9.4	0.9731	
05	No	American Avocet	May 23	U	U	<3	9.9	0.9956	
06	Yes	Black-necked Stilt	May 27	U	U	<3	5.5	0.7404	
07	Yes	Black-necked Stilt	May 27	U	U	<3	4.8	0.6812	
08	Yes	Black-necked Stilt	May 28	U	U	<3	6.2	0.7924	
09	No	Black-necked Stilt	June 02	L	N	20	28.5	1.4548	
10	Yes	Black-necked Stilt	June 04	L	U	3-6	5.1	0.7076	
11	Yes	Black-necked Stilt	June 04	U	U	<3	8.6	0.9345	
12	No	Black-necked Stilt	June 04	U	U	<3	14.1	1.1492	
13	No	American Avocet	June 04	U	U	<3	12.2	1.0864	
14	No	American Avocet	June 04	L	U	3-6	10.8	1.0334	
15	Yes	Black-necked Stilt	June 04	U	U	<3	3.5	0.5441	
16	Yes	Black-necked Stilt	June 04	L	U	3-6	5.2	0.7160	
17	Yes	Black-necked Stilt	June 04	L	U	3-6	5.0	0.6990	
18	Yes	Black-necked Stilt	June 04	L	U	3-6	5.6	0.7482	
19	Yes	Black-necked Stilt	June 04	L	N	15-16	4.4	0.6435	
20	No	Black-necked Stilt	June 10	L	N	18-19	26.0	1.4150	
Arith/**Geo Mean**							12.4	0.9784	**9.5**
SD							10.1	0.3127	**2.1**
SE								0.1398	**1.4**
95% CI								0.7043	**5.1**
								1.2525	**17.9**

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

Table 7. Reference area Red-winged Blackbird egg-selenium concentrations at Panoche Drainage District's San Joaquin River water Quality Improvement Project.

ID Number	Species	Date 2003	Embryo Condition[a]	Embryo Status[b]	Embryo Age (days)	Selenium (ppm dry wt)	Log base 10	Anti-log
01	R.W. Blackbird	May 06	U	U	yolk	9.0	0.9542	
02	R.W. Blackbird	May 06	U	U	yolk	6.4	0.8062	
03	R.W. Blackbird	May 06	U	U	yolk	10.2	1.0086	
04	R.W. Blackbird	May 06	U	U	yolk	10.0	1.0000	
05	R.W. Blackbird	May 06	U	U	yolk	8.3	0.9191	
06	R.W. Blackbird	May 23	U	U	yolk	5.3	0.7243	
07	R.W. Blackbird	May 23	U	U	yolk	3.8	0.5798	
08	R.W. Blackbird	May 23	U	U	yolk	5.4	0.7324	
09	R.W. Blackbird	May 23	U	U	yolk	3.1	0.4914	
10	R.W. Blackbird	May 23	U	U	yolk	4.3	0.6335	
11	R.W. Blackbird	May 23	U	U	yolk	3.9	0.5911	
12	R.W. Blackbird	May 23	U	U	yolk	4.0	0.6021	
13	R.W. Blackbird	June 02	U	U	yolk	6.5	0.8129	
14	R.W. Blackbird	June 02	U	U	yolk	4.0	0.6021	
15	R.W. Blackbird	June 02	U	U	yolk	4.4	0.6435	
16	R.W. Blackbird	June 02	U	U	yolk	3.9	0.5911	
17	R.W. Blackbird	June 02	U	U	yolk	3.3	0.5185	
18	R.W. Blackbird	June 02	U	U	yolk	3.6	0.5563	
19	R.W. Blackbird	June 02	U	U	yolk	4.7	0.6721	
20	R.W. Blackbird	June 02	U	U	yolk	3.9	0.5911	
Arith/**Geo Mean**						5.4	0.7015	**5.0**
SD						2.3	0.1619	**1.5**
SE							0.0724	**1.2**
95% CI							0.5596	**3.6**
							0.8434	**7.0**

[a]) L= Live, D= Dead, U= Unknown, [b]) N= Normal, A= Abnormal, U= Unknown.

EGG-SELENIUM ANALYSIS

Rice Field Effects

Twenty Killdeer eggs and 20 recurvirostrid eggs were collected at the Panoche reference area. Several rice fields, flooded with fresh irrigation water, were present within the reference area.

During the initial analysis, data were included for eggs collected from throughout the reference area, as well as eggs collected from rice fields and elsewhere. However, the initial analysis indicated that eggs from the rice fields consistently contained lower levels of selenium in relation to those collected elsewhere on the reference site. Thus, a secondary analysis was conducted. This analysis tested for potential differences in egg-selenium levels of eggs collected from rice fields versus eggs collected elsewhere within the reference area. Nine Killdeer eggs were collected from rice fields, and 11 Killdeer eggs were collected from reference sites removed from rice fields. Ten recurvirostrid eggs were collected from rice-field locations and an additional 10 were collected from locations outside of rice fields.

Using STATA (Stata Corp 1995), a multiple regression analysis was used to examine the relationship between egg-selenium levels in eggs collected from rice fields versus eggs collected elsewhere within the reference area. Egg-selenium levels were significantly lower in eggs collected at rice fields compared to eggs collected elsewhere within the reference area (Table 8). Selenium levels also were higher among recurvirostrid eggs relative to Killdeer eggs. However, there was also significant interaction between bird species and rice presence (Table 8), indicating that the relation between egg-selenium concentration and bird species differed between rice fields and the other sites in the reference area. Specifically, the interaction reflects an insignificant difference in selenium concentration among Killdeer eggs when rice vs. no rice sites (t-test, $P = 0.9$) are compared, and a significantly higher selenium levels among recurvirostrid eggs at the general reference site locations compared to the rice fields (t-test, $P < 0.0001$).

Rice field conditions differed from the remainder of the reference area, in both the presence of large bodies of freshwater, within the rice fields themselves, and in the absence of open-drainage ditches. Therefore, eggs collected from rice fields were removed from the second level of analysis to better understand the relative contributions of the project versus the local regional effect on egg selenium levels. Similarly, data from five Red-winged Blackbird reference area eggs were removed for further analysis after it was learned that they were also collected from an area dissimilar to the reference area. The geometric mean of these five eggs was more than double the remainder of the reference area (8.6 ppm and 4.2 ppm respectively).

Table 8. Data from multiple regression analysis used to examine selenium levels (log-base 10) in Killdeer and Recurvirostrid eggs collected at rice-field and reference area locations outside rice fields.

Term	Coefficient	*F*-value	*P*-value	df
Model: $F_{[5,90]}$ = 33.09, 73.4% of variance explained.				
Main effects:				
Rice fields	(-)	8.69	<0.01	1
Species	(-)	4.95	<0.05	1
Interaction:				
Rice fields * Species		27.75	<0.0001	1
The interaction between "species" and "site" was tested after the main effects for the two respective variables had been tested.				

Project Site and Reference Area (excluding rice) Comparisons

The regression model explained 78 percent of the variation in egg-selenium concentration (Table 9). Egg-selenium levels for each of the three species groups were significantly higher in eggs collected at the project site relative to eggs collected at the reference area (t-tests, all P <0.01).

Egg-selenium concentrations among the three species groups also differed significantly when compared across sites. Recurvirostrid egg-selenium levels were significantly higher than Killdeer or Red-winged Blackbird eggs, and Killdeer eggs contained higher levels of selenium than those of blackbirds (Sidak tests, all P < 0.01, Table 9).

However, there was also a significant interaction between species groups and study site (Table 9), indicating that the relationship between egg-selenium concentration and species groups differed between study sites. Specifically, this reflected the significant difference in selenium concentration among all three species groups at the project site, compared to egg-selenium concentrations between Killdeer and blackbird eggs at the reference area (Table 10). At the reference area and the project site, recurvirostrid egg selenium was significantly higher than the other two species.

Table 9. Data from multiple regression analysis used to examine selenium levels (log-base 10) in three bird species groups as related to the Panoche project site vs. reference area.

Term	Coefficient	*F*-value	*P*-value	df
Model: $F_{[5,90]}$ = 63.25, 77.9% of variance explained.				
Main effects:				
Site	(-)	**50.10**	**<0.0001**	**1**
Species	-----	**104.34**	**<0.0001**	**2**
Interaction:				
Site * Species	-----	**5.91**	**<0.01**	**2**
Species was also included as an independent variable in this analysis. The interaction between "species" and "site" was tested after the main effects for the two respective variables had been tested.				

Table 10. Geometric mean egg-selenium concentrations from Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

Selenium			
Species **Location**	**n**	**Geo. Mean** **ppm se (dry wt)**	**Range**
Killdeer			
Project Site	20	12.5	5.8-33.5
Off-site Reference Samples	11	4.0	2.6-10.2
Recurvirostrids			
Project Site	20	39.0	9.8-98.9
Off-site Reference Samples	10	17.2	9.4-40.6
Red-winged Blackbirds			
Project Site	20	5.9	4.5-11.0
Off-site Reference Samples	15	4.2	3.1-6.5
Significance difference (t =4.42, df = 8, P <0.01) between sites.			

Flooded Pasture Effects

A pasture that is part of the SJRIP project site located in Section 12 on the south side of the Main Canal (Figure 2) was accidentally flooded in late April 2003 and remained flooded through mid-May. Many waterfowl were attracted to the flooded pasture as were a number of Killdeer, Black-necked Stilts, and American Avocets, which nested in the pasture, or in the vicinity of the pasture. A refined analysis of the project-site data indicated that eggs from the flooded pasture in Section 12 consistently contained higher levels of selenium relative to eggs collected elsewhere on the project site. Thus, an analysis that tested for potential differences in egg-selenium levels in eggs collected from the flooded pasture versus eggs collected elsewhere within the project site and eggs collected from the reference area (a 3-way comparison) was conducted. Eleven of the Killdeer eggs and 14 of the recurvirostrid eggs collected from the project site were from this pasture and its immediate vicinity, while nine of the Killdeer eggs and six of the recurvirostrid eggs were collected from the remainder of the project site (Tables 2 and 3). No Red-winged Blackbird eggs were collected from the flooded pasture or its vicinity.

Using STATA (Stata Corp 1995), a multiple regression analysis was used to conduct the 3-way analysis. The regression model explained 83% of the variance in egg selenium (Table 11). Egg selenium differed among pond treatments and between the two species groups. Specifically, egg selenium was higher in eggs collected at the flooded pasture relative to the remainder of the project site and the reference site (Sidak tests, all $P < 0.01$, Table 12); egg selenium did not differ between the reference and remainder of the project site ($P > 0.2$). Egg-selenium was higher among recurvirostrids than Killdeer.

A significant interaction between the effects of species and pasture treatment on egg-selenium (Table 11) reflected significantly higher egg selenium values at the flooded pasture compared to the non-flooded pasture and reference pasture among recurvirostrids (Sidak tests, both $P < 0.0001$). Recurvirostrid eggs collected from this pasture contained significantly higher egg-selenium concentrations than recurvirostrid eggs collected from either the remainder of the project site or the reference area ($P = 0.9$, Table 2). There was no significant difference in recurvirostrid egg-selenium concentration between eggs from the remainder of the project site and the reference area. There was no significant difference in selenium concentrations between Killdeer eggs collected from the flooded pasture and eggs collected from the remainder of the project site ($P = 0.5$, Table 12), both of which contained significantly higher selenium concentrations than eggs collected from the reference area ($P < 0.0001$).

Table 11. Data from multiple regression analysis used to examine selenium levels (log-base 10) in two bird species groups as related to the Panoche project site vs. reference area.

Term	Coefficient	*F*-value	*P*-value	df
Model: $F_{[5,55]}$ = 53.02, 82.8% of variance explained.				
Main effects:				
Site	(-)	**40.23**	**<0.0001**	**2**
Species	-----	**95.51**	**<0.0001**	**1**
Interaction:				
Site * Species	-----	**9.50**	**<0.01**	**2**
Species was also included as an independent variable in this analysis. The interaction between "species" and "site" was tested after the main effects for the two respective variables had been tested.				

Table 12. Comparisons of Geometric mean egg-selenium concentrations including the accidentally flooded pasture in Section 12.

Selenium			
Species **Location**	**n**	**Geo. Mean** **Ppm se (dry wt)**	**Range**
Killdeer			
Accidentally Flooded Pasture	11	14.0	7.4-33.5
Rest of Project Site	9	10.9	5.8-14.1
Off-site Reference Samples	11	4.0	2.6-10.2
Recurvirostrids			
Accidentally Flooded Pasture	14	58.2	32.8-98.9
Rest of Project Site	6	15.4	9.8-32.3
Off-site Reference Samples	10	17.2	9.4-40.6
Significance difference (t =4.42, df = 2, P <0.001) between sites.			

EGG-BORON ANALYSIS

Boron concentration levels differed significantly among the three species groups due to higher levels in Red-winged Blackbird eggs, lower levels in Killdeer eggs, and intermediate levels among recurvirostrid eggs (Sidak tests, all P < 0.01). There was a significant interaction between the effects of species group and the project site (Table 11), indicating the relation between egg-boron concentrations and project site differed among species group. This interaction reflected significantly higher egg-boron concentrations at the project site, in comparison to the reference area, among Killdeer eggs (t-test, P < 0.0001), but not among recurvirostrids or Red-winged

Blackbird eggs (Table 11). In addition, boron concentration at the project site was significantly higher among blackbird eggs in comparison to Killdeer or recurvirostrid eggs (Table 12), but at the reference area, the boron concentration was significantly higher among recurvirostrid and blackbird eggs compared to Killdeer eggs (Sidak tests, all $P < 0.001$). The raw boron data is presented in appendices A, B and C.

Table 13. Data from multiple regression analysis used to examine boron levels (log base 10) in three bird species as related to wetland site (Project vs. Reference).

Term	Coefficient	*F*-value	*P*-value	df
Model: $F_{[5,90]} = 17.70$, 36.6% of variance explained				
Main effects:				
Site	ns	3.60	0.08	1
Species	-----	22.55	<0.0001	2
Interaction:				
Site * Species	ns	11.19	0.0001	2
Species was also included as an independent variable in this analysis. The interaction between “species” and “site” was tested after the main effects for the two respective variables had been tested. ns = not significant.				

Table 14. Geometric mean egg-boron concentrations from Panoche Drainage District's San Joaquin River Water Quality Improvement Project.

Boron			
Species **Location**	**n**	**Geo. Mean** **Ppm B (dry wt)**	**Range**
Killdeer			
Project Site	20	2.49	1.10-5.26
Off-site Reference Samples	11	1.03	0.42-2.99
Recurvirostrids			
Project Site	20	2.46	0.69-4.33
Off-site Reference Samples	10	3.62	0.83-14.70
Red-winged Blackbirds			
Project Site	20	5.06	1.53-12.5
Off-site Reference Samples	15	4.36	2.89-7.69
Significance difference ($t = 4.42$, $df = 8$, $P < 0.01$) between sites.			

QUALITY ASSURANCE/QUALITY CONTROL ANALYSIS

The selenium recovery rate for egg samples spiked with 80 ng of selenium ranged between 93.5 percent and 108 percent with a mean selenium recovery rate of 98 percent (Appendix D). Additionally, an average value of 0.760 ug/g Se was obtained on NIST Standard Reference Material 1577b (certified value = 0.73 $\pm$ 0.06 ug/g). The standard deviation of duplicate egg samples ranged between 0.0000 and 0.9263 with a mean standard deviation of 0.1131 (Appendix D).

The standard deviation of boron results from 14 duplicate egg samples ranged between 0.0071 and 0.2482, and the mean standard deviation was 0.0629 (Appendix E).

DISCUSSION

The census data indicates that the project site is utilized by bird species common in San Joaquin Valley agricultural habitats. Both species diversity and relative abundance are lower than expected in native, undisturbed habitats. The tall vegetation within several pastures provided nesting habitat for Red-winged Blackbirds. Irrigation of pastures and alfalfa provide temporary foraging opportunities for birds such as White-faced Ibis (*Plegadis chihi*), Whimbrels and blackbirds. A pasture in Section 12, on the south side of the Outside Canal, was inadvertently flooded in late April and ponding remained through the second week of May. This field attracted migrant waterfowl, such as Mallards (*Anas platyrhynchos*) and Cinnamon Teal (*Anas cyanoptera*), and shorebirds, such as Black-bellied Plovers, Western Sandpipers and Long-billed Dowitchers (*Limnodromus scolopaceus*). The flooded field also attracted Killdeer, Black-necked Stilts and American Avocets, many of which nested in the vicinity.

Swainson's Hawks (*Buteo swainsoni*), which are listed as threatened by the state of California, were observed foraging on the project site. As in 2002, one pair of Swainson's Hawks successfully nested just north of the project site. Three species listed as "species of concern" by the state of California, the Burrowing Owl (*Athene cunicularia*), the Loggerhead Shrike (*Lanius ludovicianus*) and the California Horned Lark (*Eremophila alpestris actia*) were observed nesting on the project site. The White-faced Ibis, another "species of concern" was observed foraging, but not nesting, on the project site.

Eggs are the best biotic indicator for selenium transfer and toxic biological effects to a species (Skorupa and Ohlendorf 1991, Ohlendorf *et al.* 1993). Less than 3-ppm (dry wt) egg-selenium is the accepted population (or *geometric mean*) background level for birds (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993, Maier and Knight 1994). Eight ppm (dry wt) egg-selenium is considered the threshold level at which the probability of impaired hatchability increases (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993, Maier and Knight 1994). Eight-ppm selenium is the approximate lower boundary for mean egg-selenium levels associated with impaired hatchability for stilts and avocets in the Tulare Lake Basin (Skorupa and Ohlendorf 1991). Ten ppm (dry wt) selenium is the lower boundary for impaired embryo viability associated with an individual egg (Skorupa and Ohlendorf 1991). The threshold for mean egg-selenium associated with increased teratogenic effects in bird populations ranges from 13 to 24 ppm (Skorupa and Ohlendorf 1991, CH2M-Hill *et al.* 1993). The Cumulative Impact Report on impacts of agricultural evaporation basins in the southern San Joaquin Valley (CH2M-Hill *et al.* 1993) used the midpoint of 18-ppm selenium as the teratogenic threshold. Ohlendorf *et al.* (1993) reported that mean egg-selenium concentrations greater than 20 ppm were associated with increased reproductive impairment at the population level.

Based on additional data collected in 1993, the embryo toxicity threshold for Black-necked Stilts is between 6 and 7-ppm selenium (Skorupa 1998). Because stilt embryos have been shown to be more sensitive than avocets to *in ovo* selenium exposure (Skorupa 1998), it is assumed safe to apply this threshold to recurvirostrids as a whole. In addition, based on updated recurvirostrid egg-selenium data, the Service has proposed increasing the performance standard for mitigation sites to a maximum geometric mean of 4.0-ppm selenium (J. Skorupa, pers. comm.).

More recently, additional papers on selenium toxicity thresholds have been published. A recent analysis of laboratory data for Mallards (CH2M-Hill 2000) suggests that there is a 10 percent depression in egg hatchability at 8.4-ppm egg-selenium concentration. Fairbrother *et al.* (1999) and Adams *et al.* (2003) have posited alternative selenium toxicity thresholds for birds. Adams *et al.* (2003) argue that about 12 to 15 ppm selenium in Mallard eggs is required to create a 10 percent depression in egg hatchability, based on a review of lab studies. The authors also argue that, based on their analysis of Service field data on stilts, a 10 percent depression in egg hatchability does not occur until a 21 to 31 ppm selenium threshold is reached. The above authors calculated threshold findings based on locating the EC 10 (*i.e.*, the concentration level at which 10 percent of the population is effected) level, whereas, Skorupa (1998) calculated the 6 to 7 ppm threshold by locating the EC 3 level.

The recurvirostrid eggs that contained the highest amounts of selenium were collected from the accidentally flooded pasture in Section 12 (geometric mean = 58.2 ppm). There was no significant difference between recurvirostrid eggs collected from the remainder of the project site (geometric mean = 15.4 ppm) and recurvirostrid eggs collected form the reference area (geometric mean = 17.2 ppm). It is likely that invertebrates in drain water that is shallowly pooled and stagnant accumulate more selenium than invertebrates in flowing through water conveyances. This indicates that by controlling flooding events such as the occurrence in the pasture in Section 12 can substantially reduce egg-selenium concentrations in recurvirostrid eggs on the project site. Panoche Drainage District has now has equipment and procedures in place to prevent a future recurrence of this flooding event, so the elevated selenium levels in recurvirostrid eggs should not occur in the future. Killdeer eggs, however, showed no significant difference with respect to eggs collected from the flooded pasture versus the remainder of the project site. The differences in results between Killdeer and the recurvirostrids could be result of a higher frequency of upland foraging by Killdeer as opposed to a higher frequency of aquatic foraging by the recurvirostrids.

Four of the recurvirostrid eggs from the project site and five of the recurvirostrid eggs from the reference area contained eggs with selenium concentrations within the range (8-18 ppm dry wt) associated with an increased probability of reduced hatchability (CH2M-Hill *et al.* 1993). The remaining 16 eggs from the project site and five recurvirostrid eggs from the reference area were in the range (>18 ppm) associated with a high probability of reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis) (CH2M-Hill *et al.* 1993).

The reference area, excluding the rice fields, contained three Killdeer eggs that were below the background standard of 3 ppm (CH2M-Hill *et al.* 1993). Seven reference, and two project site Killdeer eggs, contained selenium concentrations within the range (3 to 7.9 ppm) associated with an increased probability of effects on avian reproduction. Fourteen Killdeer eggs from the project site and one from the reference area contained selenium concentrations within the range (8-18 ppm dry wt) associated with an increased probability of reduced hatchability. The remaining four Killdeer eggs from the project site were in the range (>18 ppm) associated with a high probability of reproductive effects, including reduced hatchability and increased occurrence of embryo deformities (teratogenesis).

Previously collected data, from various freshwater sites in the San Joaquin Valley, detected low levels of egg-selenium content within Killdeer eggs (Table 13). Fifteen of the 18 Killdeer eggs (83 percent) contained less than 2-ppm selenium. Seventeen of the 18 eggs (94 percent) contained less than 2.3 ppm selenium. The median geometric mean egg-selenium content for the 11 freshwater sites is 1.7 ppm. The elevated selenium levels found in the reference eggs for Killdeer, collected off of the project site (mean = 6.7 ppm, range 5.2 - 8.6 ppm), indicates that this set of eggs is not a true background, but rather an indicator of the ambient selenium exposure from the project area. All of the Killdeer nests, from which eggs were collected both on and off the project site, were adjacent to, or in close proximity of, open drainwater ditches. It is likely that these drainwater ditches were the source of elevated selenium levels found in the sampled eggs.

Table 15. Killdeer egg-selenium content from San Joaquin Valley freshwater sites.

Reference Site	Sample Size	Geometric Mean Egg Selenium (ppm)
1988 Semitropic Storage Basin	2	1.9
1989 Corcoran Sewage Ponds	3	1.8
1991 Corcoran Sewage Ponds	1	1.7
1991 Kern NWR	1	0.6
1993 Kern NWR	2	1.2
1993 Pixley NWR	1	1.0
1994 Westlake Demo Wetland	1	2.2
1994 Buena Vista Canal	2	1.1
1995 Hacienda East Flood Basin	1	1.7
1996 Westlake Demo Wetland	3	2.1
1997 Los Banos WMA	1	2.2

Source: J. P. Skorupa, USFWS, unpublished data.

A sampling of previously collected data from several freshwater sites throughout the western States, indicates that normal background egg-selenium concentration for Red-winged Blackbird eggs is approximately 1 to 3 ppm. For example, in 1995 Butler *et al*. found and an average of 1.6-ppm egg-selenium in six Red-winged Blackbird eggs collected in Dawson Draw, Colorado. Samples of water (< 1ppb Se), algae (< 1 ppm Se) and a Sora (*Porzana carolina*) egg (1. 7 ppm Se) taken from the same site indicate a selenium normal environment. Thirty-one Red-winged Blackbird eggs collected at a gravel pit along the Los Pinos River in Colorado averaged 2.7 ppm (Butler *et al*. 1993). Again, algae samples (0.2 ppm Se) indicate a selenium normal environment.

In contrast, five eggs randomly sampled in 2000 from Red Rock Ranch, a highly selenium contaminated site, showed egg selenium concentrations of 5.3, 6.2, 7.8, 8.2 and 8.8 ppm (geometric mean = 7.1 ppm) (J. Skorupa, unpublished data.). Though not conclusive, these data indicate that Red-winged Blackbird eggs containing selenium concentrations as low as 5 ppm could be considered elevated. Selenium embryo toxicity thresholds for Red-winged Blackbirds are less well known than the shorebird thresholds described above.

It has been suggested that boron impacts wildlife at the evaporation basins in the San Joaquin Valley (Ohlendorf *et al.* 1993). Boron has only one oxidation state (+3), with boric acid being the primary form in evaporation basins, but may convert to borax as evaporation concentrates the salts (Tanji and Grismer 1989). Boron bioconcentrates in aquatic organisms (plants and invertebrates), but evidence is lacking that biomagnification occurs in aquatic ecosystems (Maier and Knight 1991). Most sets of avian eggs from evaporation basins average less than 5-ppm boron (Ohlendorf *et al.* 1993). Current information indicates that slightly elevated boron in eggs does not cause embryo toxicity (Ohlendorf *et al.* 1993).

Egg-boron concentrations at the project site were higher in Red-winged Blackbirds than in both Killdeer and recurvirostrids, while the opposite was true of selenium. A possible explanation is that boron is more readily absorbed by plants than selenium (Maier and Knight 1991). Red-winged Blackbirds consume a higher percentage of plant material as diet, thus both increasing dietary exposure to boron and decreasing dietary exposure to selenium. The boron analysis of the Red-winged Blackbird eggs collected from the project site (mean = 5.06 ppm, range = 1.53-12.5 ppm), the reference Red-winged Blackbird eggs (mean = 4.36 ppm, range = 2.89-7.69 ppm) and the reference area recurvirostrid eggs (mean = 3.62 ppm, range = 0.83-14.70 ppm) indicated that the egg-boron concentrations in the species groups were slightly above the 3-ppm dry weight background level. The presence of elevated boron-egg content indicates that eggs collected from the project site should continually be monitored for boron.

The elevated selenium levels in reference recurvirostrid and Killdeer eggs, collected in the vicinity of the project site, indicate that pathways to selenium exposure may exist outside of the immediate project site. Especially when considering the background levels in true control Killdeer eggs, which were collected elsewhere in the San Joaquin Valley, are considered. Thus, selenium contamination at this site may be complex in relation to the agricultural drainwater basin systems.

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APPENDIX A. KILLDEER EGG-BORON CONCENTRATIONS AT PANOCHE DRAINAGE DISTRICT'S SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT.

Project Site				Reference Area			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	2.64	0.4216		01	2.99	0.4757	
02	3.20	0.5051		02	0.51	-0.2924	
03	2.05	0.3118		03	1.79	0.2529	
04	1.56	0.1931		04	1.34	0.1271	
05	2.26	0.3541		05	2.74	0.4378	
06	1.83	0.2625		06	2.01	0.3032	
07	3.44	0.5366		07	0.77	-0.1135	
08	2.90	0.4624		08	0.50	-0.3010	
09	3.32	0.5211		09	0.58	-0.2366	
10	3.40	0.5315		10	0.73	-0.1367	
11	1.10	0.0414		11	0.47	-0.3279	
12	1.40	0.1461		12	0.66	-0.1805	
13	1.15	0.0607		13	1.92	0.2833	
14	1.87	0.2718		14	1.48	0.1703	
15	3.53	0.5478		15	2.28	0.3579	
16	5.26	0.7210		16	1.35	0.1303	
17	3.83	0.5832		17	1.21	0.0828	
18	3.16	0.4997		18	3.09	0.4900	
19	3.14	0.4969		19	1.09	0.0374	
20	2.92	0.4654		20	0.42	-0.3768	
Arith/**Geo Mean**	2.70	0.3967	**2.5**	Arith/**Geo Mean**	1.40	0.0592	**1.1**
SD	1.04	0.1841	**1.5**	SD	0.87	0.2873	**1.9**
SE		0.0823	**1.2**	SE		0.1285	**1.3**
95% CI		0.2353	**1.7**	95% CI		-0.1927	**0.6**
		0.5581	**3.6**			0.3110	**2.0**

APPENDIX B. RECURVIROSTRID EGG-BORON CONCENTRATIONS AT PANOCHE DRAINAGE DISTRICT'S SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT.

Project Site				Reference Area			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	2.22	0.3464		01	9.06	0.9571	
02	3.21	0.5065		02	3.60	0.5563	
03	2.63	0.4200		03	3.58	0.5539	
04	4.33	0.6365		04	2.32	0.3655	
05	2.28	0.3579		05	2.58	0.4116	
06	2.48	0.3945		06	1.05	0.0212	
07	3.03	0.4814		07	0.72	-0.1427	
08	2.66	0.4249		08	1.42	0.1523	
09	2.66	0.4249		09	3.61	0.5575	
10	2.32	0.3655		10	4.17	0.6201	
11	2.08	0.3181		11	0.61	-0.2147	
12	1.94	0.2878		12	4.23	0.6263	
13	2.67	0.4265		13	0.83	-0.0809	
14	1.94	0.2878		14	14.70	1.1673	
15	4.09	0.6117		15	0.75	-0.1249	
16	2.93	0.4669		16	0.91	-0.0410	
17	4.22	0.6253		17	0.63	-0.2007	
18	0.69	-0.1612		18	1.08	0.0334	
19	2.95	0.4698		19	0.80	-0.0969	
20	1.33	0.1239		20	2.96	0.4713	
Arith/**Geo Mean**	2.63	0.3907	**2.5**	Arith/**Geo Mean**	2.98	0.2796	**1.9**
SD	0.90	0.1789	**1.5**	SD	3.43	0.4045	**2.5**
SE		0.0800	**1.2**	SE		0.1809	**1.5**
95% CI		0.2339	**1.7**	95% CI		-0.0749	**0.8**
		0.5476	**3.5**			0.6342	**4.3**

APPENDIX C. RED-WINGED BLACKBIRD EGG-BORON CONCENTRATIONS AT PANOCHE DRAINAGE DISTRICT'S SAN JOAQUIN RIVER WATER QUALITY IMPROVEMENT PROJECT.

Project Site				Reference Area			
ID Number	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**	**ID Number**	**Boron (ppm dry wt)**	**Log Base 10**	**Anti-log**
01	4.46	0.6493		01	6.60	0.8195	
02	4.53	0.6561		02	5.04	0.7024	
03	4.11	0.6138		03	3.83	0.5832	
04	4.17	0.6201		04	8.95	0.9518	
05	4.29	0.6325		05	5.18	0.7143	
06	4.14	0.6170		06	5.90	0.7709	
07	6.40	0.8062		07	3.99	0.6010	
08	8.30	0.9191		08	6.39	0.8055	
09	12.50	1.0969		09	3.91	0.5922	
10	7.03	0.8470		10	3.44	0.5366	
11	8.04	0.9053		11	3.32	0.5211	
12	3.80	0.5798		12	2.85	0.4548	
13	3.92	0.5933		13	6.75	0.8293	
14	3.95	0.5966		14	5.12	0.7093	
15	6.74	0.8287		15	3.12	0.4942	
16	9.31	0.9689		16	5.25	0.7202	
17	1.53	0.1847		17	2.99	0.4757	
18	4.28	0.6314		18	2.89	0.4609	
19	4.93	0.6928		19	7.69	0.8859	
20	4.36	0.6395		20	5.45	0.7364	
Arith/**Geo Mean**	5.54	0.7039	**5.1**	Arith/**Geo Mean**	4.93	0.6683	**4.7**
SD	2.49	0.1932	**1.6**	SD	1.73	0.1506	**1.4**
SE		0.0864	**1.2**	SE		0.0673	**1.2**
95% CI		0.5346	**3.4**	95% CI		0.5363	**3.4**
		0.8733	**7.5**			0.8002	**6.3**

APPENDIX D: SELENIUM ANALYSIS QUALITY ASSURANCE/QUALITY CONTROL RESULTS

Selenium Control Spikes.

ID Number	Tissue	Spiked Selenium (ng)	% Recovery
PDP-K-16	egg	80	93.9
PDP-RC-04	egg	80	93.9
PDP-RC-14	egg	80	97.8
PDR-P-04	egg	80	108
PDR-R-12	egg	80	94.1
PDP-B-11	egg	80	93.5
PDP-B-17	egg	80	105
PDR-B-10	egg	80	99.5
BZA-03	egg	80	103
BZA-05	egg	80	108
BZE-05	egg	80	96
LHE-03	egg	80	102
		Mean	98.0
		Standard deviation	6.03

Additionally, an average value of .760 ug/g Se was obtained on NIST Standard Reference Material 1577b (certified value = .73 $\pm$ 0.06 ug/g).

Appendix D. Selenium QA/QC Summary, 2003.
Duplicates. (SD = Standard Deviation)

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
PDP-K1	1	5.37	PDR-K5	1	1.09
	2	5.32		2	1.07
SD*		0.0354		3	1.13
PDP-K2	1	3.94	SD		0.0306
	2	3.89	PDR-K6	1	2.69
SD		0.0354		2	2.68
PDP-K3	1	3.89		3	2.69
	2	3.97	SD		0.0058
SD		0.0566	PDR-K7	1	0.953
PDP-K4	1	2.31		2	0.939
	2	2.27		3	0.979
	3	2.14	SD		0.0203
	4	2.19	PDR-K8	1	0.927
SD		0.0768		2	0.948
PDP-K5	1	1.96		3	1.010
	2	1.95	SD		0.0432
	3	2.09	PDR-K9	1	1.13
	4	2.02		2	1.12
SD		0.0645		3	1.15
PDP-K6	1	4.80	SD		0.0153
	2	4.79	PDP-K10B	1	4.64
SD		0.0071		2	4.75
PDP-K7	1	2.72	SD		0.0778
	2	2.78	PDR-K11	1	0.832
	3	2.94		2	0.900
	4	2.81		3	0.898
SD		0.0929	SD		0.0387
PDP-K8	1	9.36	PDR-K12	1	1.06
	2	9.15		2	1.04
SD		0.1485		3	1.07
PDP-K9	1	3.90	SD		0.0153
	2	3.98	PDR-K13	1	0.935
SD		0.0566		2	0.908
				3	0.959
			SD		0.0255

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

PDP-K10A	1	1.04	PDR-K14	1	1.45
	2	1.11		2	1.47
	3	1.15		3	1.49
	4	1.19	SD		0.0200
SD		0.0640	PDR-K15	1	0.686
PDP-K11	1	2.70		2	0.663
	2	2.77		3	0.681
	3	2.83	SD		0.0121
SD		0.0651	PDR-K16	1	1.06
PDP-K 12	1	2.49		2	1.09
	2	2.58		3	1.12
	3	2.55	SD		0.0300
SD		0.0458	PDR-K17	1	0.973
PDP-K13	1	2.06		2	1.00
	2	2.09		3	1.04
	3	2.21	SD		0.0337
	4	2.19	PDR-K18	1	1.69
SD*		0.0737		2	1.74
PDP-K14	1	2.54		3	1.80
	2	2.66	SD		0.0551
	3	2.75	PDR-K19	1	0.84
	4	2.69		2	0.82
SD		0.0883		3	0.84
PDP-K15	1	4.70	SD		0.0132
	2	4.74	PDR-K20	1	0.757
SD		0.0283		2	0.714
PDP-K16	1	3.59	SD		0.0304
	2	3.65	PDP-RC1	1	17.2
SD		0.0424		2	18.2
PDP-K 17	1	2.84	SD		0.7071
	2	2.33	PDP-RC2	1	8.97
	3	2.97		2	8.83
	4	2.94	SD		0.0990
SD		0.2986	PDP-RC3	1	15.8
PDP-K 18	1	3.93		2	15.3
	2	4.11	SD		0.3536
SD		0.1273	PDP-RC4	1	12.8
				2	12.6
			SD		0.1414

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

PDP-K 19	1	3.50	PDP-RC5	1	21.2
	2	3.78		2	21.3
SD		0.1980	SD		0.0707
PDP-K 20	1	1.66	PDP-RC6	1	9.53
	2	1.66		2	9.30
	3	1.32	SD		0.1626
	4	1.41	PDP-RC7	1	9.33
SD		0.1742		2	8.99
PDR-K1	1	2.03		3	8.45
	2	2.02	SD		0.4438
	3	2.27	PDP-RC9	1	13.4
SD		0.1415		2	12.3
PDR-K2	1	0.783	SD		0.7778
	2	0.747	PDP-RC 11	1	18.8
	3	0.792		2	18.7
SD		0.0238	SD		0.0707
PDR-K3	1	0.733	PDP-RC 13	1	16.5
	2	0.702		2	16.0
	3	0.730	SD		0.3536
SD		0.0171	PDP-RC 15	1	3.58
PDR-K4	1	0.933		2	3.68
	2	0.932	SD		0.0707
	3	0.982	PDP-RC17	1	5.97
SD		0.0286		2	6.64
PDP-RC8	1	19.7	SD		0.4738
	2	18.6	PDP-RC19	1	19.2
SD		0.7778		2	18.9
PDP-RC10	1	18.8	SD		0.2121
	2	18.1	PDR-R1	1	10.1
SD		0.4950		2	10.6
PDP-RC 12	1	15.7	SD		0.3536
	2	15.2	PDR-R3	1	4.99
SD		0.3536		2	4.75
PDP-RC 14	1	2.57	SD		0.1697
	2	2.74	PDR-R5	1	2.61
SD		0.1202		2	2.60
PDP-RC 16	1	8.12		3	2.61
	2	8.43	SD		0.0058
SD		0.2192			

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

PDP-RC 18	1	2.67	PDR-R7	1	1.19
	2	2.73		2	1.19
SD		0.0424	SD		0.0000
PDP-RC 20	1	2.69	PDR-R9	1	7.64
	2	2.65		2	6.46
SD		0.0283		3	6.77
PDR-R2	1	6.15	SD		0.6117
	2	6.05	PDR-R11	1	2.22
SD		0.0707		2	2.27
PDR-R4	1	2.29	SD		0.0354
	2	2.43	PDR-R13	1	3.03
SD		0.0990		2	3.16
PDR-R6	1	1.3	SD		0.0919
	2	1.3	PDR-R15	1	0.875
	3	1.4		2	0.984
SD		0.0666	SD		0.0771
PDR-R8	1	1.05	PDR-R17	1	1.23
	2	1.89		2	1.31
SD		0.5940		3	1.28
PDR-R10	1	1.32	SD		0.0404
	2	1.40	PDR-R19	1	1.04
SD		0.0566		2	1.03
PDR-R12	1	3.8		3	1.03
	2	4.0	SD		0.0058
SD*		0.1273	PDP-B1	1	0.924
PDR-R14	1	2.52		2	0.913
	2	2.70	SD		0.0078
SD		0.1273	PDP-B3	1	0.991
PDR-R16	1	1.12		2	1.04
	2	1.15	SD		0.0346
	3	1.17	PDP-B5	1	1.17
SD		0.0252		2	1.20
PDR-R18	1	1.42	SD		0.0212
	2	1.35	PDP-B7	1	0.946
	3	1.42		2	0.978
SD		0.0404	SD		0.0226
PDR-R20	1	6.58	PDP-B9	1	0.958
	2	6.63		2	0.954
SD		0.0354	SD		0.0028

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

PDP-B2	1	1.12	PDP-B11	1	0.860
	2	1.17		2	0.908
SD		0.0354	SD		0.0339
PDP-B4	1	1.01	PDP-B13	1	1.07
	2	1.05		2	1.01
SD		0.0283	SD		0.0424
PDP-B6	1	0.931	PDP-B15	1	1.04
	2	0.970		2	1.06
SD		0.0276	SD		0.0141
PDP-B8	1	0.932	PDP-B17	1	2.36
	2	0.959		2	2.24
SD		0.0191	SD		0.0849
PDP-B10	1	1.02	PDP-B19	1	1.14
	2	1.05		2	1.17
SD		0.0212	SD		0.0212
PDP-B12	1	1.38	PDR-B1	1	1.73
	2	2.69		2	1.62
SD		0.9263	SD		0.0778
PDP-B14	1	2.0	PDR-B3	1	1.84
	2	2.0		2	1.83
SD		0.0000	SD		0.0071
PDP-B16	1	0.801	PDR-B5	1	1.38
	2	0.821		2	1.36
SD		0.0141	SD		0.0141
PDP-B18	1	0.911	PDR-B7	1	0.835
	2	0.737		2	0.743
	3	0.871		3	0.812
	4	0.728	SD		0.0479
SD		0.0930	PDR-B9	1	0.564
PDP-B20	1	0.736		2	0.568
	2	0.755	SD		0.0028
SD		0.0134	PDR-B11	1	0.921
PDR-B4	1	1.61		2	0.857
	2	1.53	SD		0.0453
SD		0.0566	PDR-B17	1	0.610
PDR-B6	1	1.04		2	0.616
	2	0.983	SD		0.0042
SD*		0.0403			

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

PDR-B8	1	1.00	PDR-B19	1	0.839
	2	0.966		2	0.802
	3	0.966	SD		0.0262
SD		0.0196	BZA-1	1	17.7
PDR-B10	1	0.783		2	17.0
	2	0.954	SD		0.4950
	3	0.779	BZA-3	1	3.01
	4	0.941		2	2.90
SD		0.0963	SD		0.0778
PDR-B12	1	0.782	BZA-5	1	2.98
	2	0.767		2	2.87
SD		0.0106	SD		0.0778
PDR-B14	1	0.687	BZE-2	1	10.9
	2	0.675		2	10.9
SD		0.0085	SD		0.0000
PDR-B16	1	0.807	BZE-4	1	7.56
	2	0.778		2	7.29
SD		0.0205	SD		0.1909
PDR-B18	1	0.670	BZG-1	1	0.575
	2	0.610		2	0.615
SD		0.0424	SD		0.0283
PDR-B20	1	0.667	BZG-3	1	0.454
	2	0.679		2	0.463
SD		0.0085	SD		0.0064
BZA-2	1	10.6	BZG-5	1	0.834
	2	10.0		2	0.829
SD		0.4243	SD		0.0035
BZA-4	1	7.93	LHE-2	1	7.67
	2	7.56		2	7.62
	3	8.77	SD		0.0354
SD		0.6200	LHE-4	1	12.3
BZE-1	1	12.8		2	12.1
	2	12.2	SD		0.1414
SD		0.4243	LHM-1	1	10.7
BZE-3	1	13.0		2	11.1
	2	13.2	SD		0.2828
	3	12.2			
SD		0.5292			

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

BZE-5	1	9.02	LHM-3	1	0.632
	2	8.38		2	0.666
SD		0.4525		3	0.630
BZG-2	1	0.533		4	0.620
	2	0.528	SD		0.0200
SD		0.0035	LHM-5	1	8.04
BZG-4	1	0.616		2	8.04
	2	0.707		3	8.26
SD		0.0643	SD		0.1270
LHE-1	1	8.9	WLS-2	1	1.59
	2	8.92		2	1.64
SD		0.0141	SD		0.0354
LHE-3	1	10.5	WLS-4	1	2.24
	2	10.4		2	2.42
SD		0.0707	SD		0.1273
LHE-5	1	12.4	TLDDC-5	1	0.895
	2	11.8		2	0.896
SD		0.4243		3	0.894
LHM-2	1	3.28	SD		0.0010
	2	3.10	TLDDS-2	1	4.97
	3	3.09		2	4.49
SD		0.1069	SD		0.3394
LHM-4	1	0.865	TLDDC-1	1	0.740
	2	0.861		2	0.734
SD		0.0028		3	0.725
WLS-1	1	1.95		4	0.739
	2	2.05	SD		0.0069
SD		0.0707	TLDDC-3	1	0.787
WLS-3	1	0.526		2	0.770
	2	0.532		3.0	0.766
SD		0.0042		3	0.800
WLS-5	1	0.597	SD*		0.0157
	2	0.622	TLDDC-4	1	0.627
SD		0.0177		2	0.617
TLDDS-1	1	4.70		3	0.617
	2	4.77	SD		0.0058
			TLDDS-4	1	4.46
SD*		0.0495		2	4.70
			SD		0.1697

Appendix D. Selenium QA/QC Summary, 2003. Duplicates (continued)

TLDDS-3	1	4.87	TLDDS-5	1	5.75
	2	5.28		2	5.76
SD		0.2899	SD		0.0071
TLDDC-2	1	1.77			
	2	1.64			
	3	1.77			
	4	1.77			
	5	1.66			
SD		0.0661			

Mean SD: 0.11309

Low SD: 0.0000
High SD:0.9263

APPENDIX E: BORON ANALYSIS QUALITY ASSURANCE/QUALITY CONTROL RESULTS

Boron QA/QC Summary, 2003.

Duplicates. (SD = Standard Deviation)

ID Number	Replication	Result Selenium	ID Number	Replication	Result Selenium
PDP-K1	1	0.780	PDR-K10	1	0.769
	2	0.740		2	1.12
SD*		0.0283	SD		0.2482
PDP-K2	1	0.940	PDR-K18	1	0.719
	2	0.870		2	0.809
SD		0.0495	SD		0.0636
PDR-K18	1	0.719	PDP-K 17	1	1.02
	2	0.809		2	1.03
SD		0.0636	SD		0.0071
PDP-K 20	1	0.771	PDR-K2	1	0.130
	2	0.761		2	0.170
SD		0.0071	SD		0.0283
PDP-RC 15	1	1.03	PDR-R9	1	0.932
	2	1.04		2	0.831
SD		0.0071	SD		0.0714
PDP-RC17	1	0.998	PDR-R11	1	0.140
	2	1.01		2	0.180
SD		0.0085	SD		0.0283
PDR-R20	1	0.739	PDR-R14	1	3.49
	2	0.769		2	3.63
SD		0.0212	SD		0.0990

Mean SD: 0.0629

Low SD: 0.0071

High SD:0.2482